

## **Instrumentation for Measuring the Bidirectional Scattering Distribution Function of Rough Surfaces**

Z.M. Zhang<sup>C,S</sup> and Q.Z. Zhu

*George W. Woodruff School of Mechanical Engineering  
Georgia Institute of Technology  
Atlanta, GA 30332, U.S.A.*

Real surfaces contain irregularities or surface roughness that depends on the processing method. The directional dependence of the radiative properties can be best described by the bidirectional scattering distribution function (BSDF). For an opaque surface, only the bidirectional reflectance distribution function (BRDF) can be observed. The BSDF is important for a complete heat transfer analysis in the environment with rough or patterned surfaces, noninvasive diagnostics, and remote sensing. Therefore, BSDFs of rough surfaces have been an attractive subject with considerable research devoted to the theory, numerical modeling, and measurement.

The BSDF measurement instrument is usually called bidirectional reflectometers or scatterometers. This presentation reviews and compares various bidirectional scatterometer designs. The main components of a bidirectional scatterometer are a light source (laser or spectrometer source), a manual or automated goniometric stage, a detector or a number of detectors, and a data acquisition system. Most instruments are from the visible to near-infrared range. In some experiments, the design was rather simple when high angular resolution is not needed. In other cases, multiple turntable and translation stages were used. In some facilities, the goniometric tables were placed in a vacuum environment. Some instruments employed multiple detectors or optic fibers to improve the sampling speed and flexibility.

Recently, we have developed a three-axis automated scatterometer (TAAS) for measuring the both in-plane and out-of-plane BSDFs with a high angular accuracy and a large dynamic range. Measurement results for coated and uncoated silicon wafers will be presented and compared to those obtained with a standard instrument at the National Institute of Standards and Technology.

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